

REMARKS

This is in response to the Office Action dated April 6, 2004. In view of the foregoing amendments and following representations, reconsideration is respectfully requested.

Initially, to facilitate the Examiner's reconsideration of the application, the specification and abstract have been reviewed and revised in order to make a number of minor clarifying and other editorial amendments. Note that the changes to the specification and abstract are submitted in the form of a substitute specification and abstract. No new matter has been added. A copy of the original specification and abstract, with the changes marked therein, is attached.

To further facilitate the Examiner's reconsideration of the application, original claims 1-20 have been canceled and replaced with new claims 21-40. Each of the new claims has been carefully drafted to ensure compliance with the requirements of 35 U.S.C. § 112, second paragraph. Note, the objections and rejections of the original claims have been overcome by the presentation of the new claims.

Next, on page 8 of the Office Action, claims 6, 8, and 11-12 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Accordingly, new independent claim 21 has been written to include substantially all of the limitations of claims 1, 2, 4 and 6. The deviations from the original claims were necessary to overcome the rejections under 35 U.S.C. 112, second paragraph, and to recite that the recessed part of the reinforcing member has an inner face that is "colored"

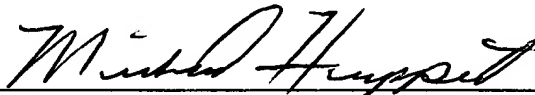
in order to suppress the reflection of light. Original claim 6 recited that the recessed part was "black". In view of the prior art of record, it does not appear to be necessary to recite the specific color of the inner face of the recessed part. Thus, it is submitted that claims 21-40 are clearly allowable over the prior art of record.

In view of the above, it is submitted that the present application is now clearly in condition for allowance. The Examiner therefore is requested to pass this case to issue.

In the event that the Examiner has any comments or suggestions of a nature necessary to place this case in condition for allowance, then the Examiner is requested to contact Applicant's undersigned attorney by telephone to promptly resolve any remaining matters.

Respectfully submitted,

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SPECIFICATION

TITLE OF THE INVENTION

Jig For Calibration of Component Recognition
Device And Component Recognition Calibration Method With
5 Using The Jig, And Component Mounting Apparatus Handling
The Calibration Jig

BACKGROUND OF THE INVENTION

The present invention relates to a calibration
10 jig for calibrating a component recognition device picking
up images of components, and a component recognition
calibration method using the calibration jig, and a
component mounting apparatus handling the calibration jig.
Electronic components ~~is~~ are an example of the above
15 component.

~~Electronic~~ These days, electronic circuit boards
~~in these days~~ are required to be improved in mount quality
with electronic components mounted correctly.

An example of a conventional electronic component
20 mounting apparatus will be described hereinbelow with
reference to Figs. 15-20. A conventional electronic
component mounting apparatus ~~is~~ is shown in Fig. 15 and
includes a board transfer device 42 for carrying in and out
circuit boards 41, a component feed device 44, an XY robot
25 45 which is equipped with a nozzle 46 and a board

recognition camera 49 and movable in X, Y directions, and an electronic component recognition camera 47.

The structure of the component recognition camera 47 is indicated in Fig. 16. It is a calibration jig 51
5 that is held at a leading end of the nozzle 46. The component recognition camera 47 is equipped with, for the purpose of picking up images of components, an LED illuminator 52 for illuminating a component held by the nozzle 46, a mirror 54 and a lens 55 arranged on an optical
10 path of the LED illuminator 52 reflected by the component, and a CCD camera 56 for receiving a light passing through the lens 55. In Fig. 16, a light of the LED illuminator 52 reflected by the calibration jig 51 is condensed by the lens 55 via the mirror 54, so that an image of the
15 calibration jig 51 is picked up by the CCD camera 56. A The reference numeral 53 represents an optical axis.

A resolution of the component recognition camera 47, and at the same time, how to measure an inclination of the component recognition camera 47 to the X, Y directions
20 in which the XY robot 45 moves, and a center position of the component recognition camera 47 will be explained below. Since the nozzle 46 is rotatable about its axis, the center position of the camera is easily detected by a—the
following method. That is, each of the images of the
25 calibration jig 51 is obtained by rotating the jig 51 every

90° through the rotation of the nozzle 46 every 90° about the axis, and then four centroids corresponding to the respective images ~~is~~are taken and thus a center of the four centroids is considered as a rotational center of the nozzle 46. For the resolution and inclination of the camera, as shown in Fig. 17, the calibration jig 51 is moved in X, Y directions in the vicinity of an outline of a recognition view field 47a of the component recognition camera 47, thereby measuring the resolution and inclination from a move amount of the calibration jig 51 over the recognition camera 47 and a move amount of the XY robot 45.

The operation of the conventional electronic component mounting apparatus 1, constituted as above, will be ~~depicted~~described below. The circuit board 41 is carried to a mount position by the board transfer device 42. The XY robot 45 moves the board recognition camera 49 to a position above the circuit board 41 and seeks a position 43 where an electronic component is to be mounted ~~to~~on the circuit board 41. Then, the XY robot 45 moves the board recognition camera 46 to a position above the component feed device 44 to recognize the electronic component to be held, and lets the nozzle 46 hold the electronic component 48. An attitude of the component 48 held by the nozzle 46 is picked up by the component recognition camera 47. ~~A~~The position of the component is corrected on the basis of the

obtained image information, and then the electronic component 48 is mounted onto the circuit board 41.

The electronic component 48 held by the nozzle 46 of the XY robot 45 is moved in X, Y directions by the XY robot 45. Meanwhile, X, Y directions of a coordinate system in the image obtained by the component recognition camera 47 recognizing the attitude of the electronic component 48 held by the nozzle 46 are different from the X, Y directions as the movement directions of the XY robot 45. Although the component recognition camera 47 is set so that the X, Y directions of the coordinate system of the component recognition camera 47 agree with the X, Y directions of the XY robot 45, a slight offset is actually present between the directions. Thus, the electronic component 48 held by the nozzle 46 cannot be mounted correctly to the circuit board 41 unless the offset is calibrated. In other words, the measurement of the resolution, inclination and center position of the component recognition camera 47, i.e., calibration of the board recognition camera 49 is important ~~so as~~ in order to correctly mount the electronic component 48 onto the circuit board 41.

Fig. 18 shows a state where the calibration jig 51 is picked up by the board recognition camera 49. Fig. 19 indicates a luminance level of an image obtained by

slicing an image of Fig. 18 in the X direction, while Fig. 20 is a luminance level of an image obtained by slicing the image of Fig. 18 in the Y direction.

As is shown in Fig. 16, the LED illuminator 52
5 irradiates a flat face 57 of the calibration jig 51, and
therefore the component recognition camera 47 picks up the
flat face 57. It is important for the calibration of the
component recognition camera 47 to clearly and stably
photograph an outline of the flat face 57. At this time,
10 an edge part of the flat face 57 photographed by the
component recognition camera 47, namely, a perpendicular
part 50 extending in a direction orthogonal to the flat
face 57 is not always in parallel to the photographed
optical axis 53. While the calibration jig 51 is
15 manufactured to make the perpendicular part 50 as small as
possible, the calibration jig 51 is easy to break ~~in~~ if its
~~shape if it is~~ minimal. As such, the perpendicular part 50
is given a certain margin of length. The light projected
from the LED illuminator 52 irradiates the perpendicular
20 part 50 as well and a faint light reflected at the
perpendicular part 50 is picked up by the CCD camera 56
which is represented by a reference numeral 58 in Fig. 18.
As shown in Figs. 19 and 20, an intensity of the reflecting
light at the flat face 57 of the calibration jig 51 is high,
25 and therefore the flat face 57 is photographed with a high

gain by the CCD camera 56, assuming a high luminance level. A shape of the flat face 57 is accordingly detected clearly. On the other hand, the perpendicular part 50 with a low intensity of the reflecting light assumes a low luminance level and is not clear in contrast as designated by luminances 59, 60 in Figs. 19 and 20. As a result, the outline of the calibration jig 51 ~~becomes~~ is not clear in the image obtained by the component recognition camera 47.

In the above state with the luminances 59 and 60 brought about, a position of the calibration jig 51 when rotated for measuring the center position of the camera, or a position of the calibration jig 51 when held by the nozzle 46 cannot be recognized easily, thus hindering stable measurement of the resolution, inclination and center position of the component recognition camera 47.

As discussed hereinabove, the offset of the component recognition camera 47 cannot be correctly measured according to the conventional calibration jig 51, and consequently the component recognition camera 47 cannot be calibrated correctly, whereby the electronic component 48 cannot be correctly and stably mounted to the circuit board 41 ~~stably~~.

SUMMARY OF THE INVENTION

The object of the present invention is therefore

to provide a calibration jig for a component recognition device and a component recognition calibration method using the jig whereby an offset and a scale of a component recognition camera can be correctly calibrated, thereby
5 stabilizing ~~mount~~the mounting accuracy of components to a to-be-mounted object and improving mount quality, and a component mounting apparatus handling the calibration jig.

In order to achieve the aforementioned objective, according to a first aspect of the present invention, there
10 is provided a calibration jig for a component recognition device to be used in making a coordinate system within a view field of the component recognition device provided for confirming an attitude of a component before the component is mounted to a to-be-mounted object, agree with a
15 coordinate system of a component holding device for holding and mounting the component to the ~~object~~object.

~~the~~The calibration jig ~~comprising~~comprises a recognition part set at a flat face, which is to be picked-up, for reflecting light to be picked up by the component
20 recognition device, arranged inside a periphery of the picked-up face, having a light reflectance different from that of the picked-up face, and for obtaining a point to be measured of the picked-up face which is a point necessary for the agreement of the coordinate systems.

25 ~~a recognition part set at a flat face, which is to be~~

~~picked-up, for reflecting light to be picked up by the
component recognition device, arranged inside a periphery
of the picked-up face, having a light reflectance
different from that of the picked-up face, and for
5 obtaining a point to be measured of the picked-up face
which is a point necessary for the agreement of the
coordinate systems.~~

According to a second aspect of the present
invention, there is provided a component recognition
10 calibration method using the calibration jig for the
component recognition ~~device according to claim 1,~~device.

~~the method comprising:~~The method comprises:

illuminating the picked-up face of the calibration
jig;

15 recognizing the recognition part by the component
recognition device thus operating a position of the
recognition part;

calculating a resolution of the component recognition
device on a basis of a result of the operation; and

20 calculating a rotational angle representing a shift of
the coordinate system of the component recognition device
to the coordinate system of the component holding device.

The calculating the resolution of the component
recognition device and the rotational angle may comprise:

25 obtaining the point to be measured of the calibration

jig on the basis of the position of the recognition part obtained through the operation;

thereafter, moving the calibration jig over the component recognition device in X, Y directions orthogonal to each other on a plane;

calculating the resolution of the component recognition device from a movement distance of the point to be measured and an actual movement distance, the movement distance being obtained by the component recognition device based on a locus of the point to be measured; and

calculating the rotational angle from a shift of a movement direction in the X or Y direction of the point to be measured to a regulated X-axis or Y-axis.

According to the calibration jig for the component recognition device in the first aspect and the component recognition calibration method in the second aspect of the present invention, the recognition part is provided at the to-be-picked-up face and a predetermined position of the calibration jig is recognized on the basis of a contrast between the picked-up face and the recognition part. Thus, in comparison with the prior art ~~that~~ in which the position of the calibration jig is recognized on the basis of an outline of the calibration jig, in the present invention the position of the calibration jig can be recognized with a higher degree of

accuracy. The resolution, etc. of the component recognition device calculated through the recognition of the predetermined position of the calibration jig are more highly accurate than in the prior art, and accordingly
5 ~~mount the~~ accuracy of mounting the component to the to-be-mounted object is stabilized and mount quality is improved.

A component mounting apparatus provided according to a third aspect of the present invention uses the calibration jig for the component recognition device of the
10 first aspect.

Since the component mounting apparatus of the third aspect uses the calibration jig for the component recognition device of the first aspect, the resolution, etc. of the component recognition device can be obtained more
15 highly accurately, so that mount accuracy for the component to the to-be-mounted object is stabilized and mount quality is improved.

20 BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and features of the present invention will become clear from the following description taken in conjunction with the preferred embodiment thereof with reference to the accompanying
25 drawings, in which:

Fig. 1 is a sectional view of a calibration jig in an embodiment of the present invention, along with showing the ~~constitution~~ construction of a component recognition device;

5 Fig. 2 is a plan view of the calibration jig of Fig. 1;

Fig. 3 is a diagram of an image of the calibration jig picked up by the component recognition device of Fig. 1;

10 Fig. 4 is a graph of a luminance distribution at an I-I part of Fig. 3;

Fig. 5 is a diagram explanatory of how to obtain a center of a frame formed by openings of the calibration jig of Fig. 1;

15 Fig. 6 is a diagram explanatory of how to obtain a rotational angle and a resolution of a camera;

Fig. 7 is a diagram explanatory of how to obtain a center of a view field of the component recognition device of Fig. 1;

20 Fig. 8 is a perspective view of a component mounting apparatus to be calibrated with the use of the calibration jig of Fig. 1;

Fig. 9 is a diagram of a reflection state of light without a groove provided at an opening part of the
25 calibration jig of Fig. 1;

Fig. 10 is a diagram of the reflection state of light with a groove provided at the opening part of the calibration jig of Fig. 1;

5 Fig. 11 is a diagram of another example of the calibration jig of Fig. 1;

Fig. 12 is a perspective view of a different example of the calibration jig of Fig. 1;

Fig. 13 is a sectional view of a state where the calibration jig of Fig. 12 is fitted to a nozzle;

10 Fig. 14 is a flow chart of a component recognition calibration operation with the use of the calibration jig of Fig. 1;

Fig. 15 is a perspective view of a conventional component mounting apparatus;

15 Fig. 16 is a diagram of a conventional calibration jig, and a component recognition device photographing the jig;

20 Fig. 17 is a diagram explanatory of how to obtain a rotational angle and a resolution of a camera with the use of the calibration jig of Fig. 16;

Fig. 18 is a diagram of an image of the calibration jig of Fig. 16;

25 Fig. 19 is a graph of a luminance level of the image in an X direction of the calibration jig of Fig. 16; and

Fig. 20 is a graph of a luminance level of the image in a Y direction of the calibration jig of Fig. 16.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

5 A calibration jig for a component recognition device in one embodiment of the present invention, a component recognition calibration method carried out with the use of the calibration jig, and a component mounting apparatus handling the calibration jig will be described
10 with reference to the drawings throughout which like parts are designated by like reference numerals.

 According to the embodiment, a component mounting apparatus is employed by way of example which holds an electronic component as a component by means of a nozzle of
15 a component holding device, and automatically mounts the electronic component onto a circuit board. The component recognition device described in the foregoing "SUMMARY OF THE INVENTION" corresponds to a device provided in the above component mounting apparatus and picks up an image of
20 an attitude of the electronic component held by the nozzle. The calibration jig for the component recognition device according to the embodiment is a jig used for calibrating a center position of a to-be-picked-up face of a camera of the component recognition device, a resolution and an
25 inclination of the component recognition device. An

example exerting a function of the "recognition part" in the "SUMMARY OF THE INVENTION" corresponds to an opening 156 of the embodiment.

5 First, the calibration jig for the component recognition device will be described. As shown in Fig. 1, a calibration jig 150 for the component recognition device according to the present embodiment consists of a rectangular thin plate 151 and a reinforcing member 152 for reinforcing the thin plate 151.

10 The thin plate 151 is formed as thin as possible so as to restrain a light from being reflected at a side face in a thicknesswise direction of the thin plate 151, as small as possible, when a pickup performance is executed by the component recognition device 107. A plurality of
15 openings 156 penetrating the thin plate 151 are arranged to be conformable in outline to the thin plate 151, as is clear from Fig. 2. Although the openings 156 are circular in the embodiment, the shape thereof is not limited to this and can be a—rectangular or the like so long as a center
20 position of each opening can be detected from a picked-up image of the component recognition device 107. As will be described later, the openings 156 are formed to obtain a point-to-be measured of the calibration jig 150 to measure a resolution of a CCD camera 175 at the component
25 recognition device 107, a rotational angle of the component

recognition device 107 and a center position of a view field of the CCD camera 175 which are basic data to correct a movement amount of a component holding device 106, etc. The rotational angle of the component recognition device 107 is an offset angle of X axes or Y axes between an XY coordinate system of the component holding device 106 and an XY coordinate system in the view field of the CCD camera 175 when origins of both coordinate systems are agreed on the same plane. Therefore, at least four openings 156, namely, 156a-156d are preferably arranged ~~correspondingly~~ so as to correspond to at least four corners of the rectangular shape as in the embodiment. For the purpose of obtaining the point-to-be measured, however, it is enough to form at least one opening at an optional position of the thin plate 151. Since the point-to-be measured is a center point of the thin plate 151 in the embodiment as will be described later, in the event only one opening is formed, that is, unless four openings are formed correspondingly to the four corners, the thin plate 151 should be rotated four times every 90° about a rotational axis of a nozzle 110 to be described later, thereby obtaining four points from a center of an area of the opening at each of four places where the opening is located respectively and detecting the center point of the thin plate 151, for example, from an intersection of diagonals or by the like manner based on

the four points.

Although the recognition part is preferred to be the openings 156 as in the embodiment, a black figure may be plotted by printing or the like manner to a to-be-picked-up face 151a if a penumbra can be picked up clearly in the image of the component recognition device 107.

The thin plate 151 in one embodiment is formed of approximately 0.1-0.2mm thick, square stainless ~~having with~~ each side ~~of having~~ an I size of 20mm. The picked-up face 151a by the component recognition camera 107 is satin finished so as to reflect the light from an LED illuminator 171 of the component recognition device 107 well and show good contrast to the openings 156. Meanwhile, each opening 156 has a diameter of 0.2-0.4mm. The openings 156 are arranged with a pitch of 1.0mm within a tolerance of $\pm 0.005\text{mm}$ in a square shape of one side of a II size of 16mm. The diameter of the opening 156 is preferably approximately twice the thickness of the thin plate 151.

As indicated in Fig. 1, the reinforcing member 152 ~~is~~ has a rectangular shape that is slightly smaller in outer dimensions than the thin plate 151, ~~having and has a~~ thickness of 1-2mm and is formed of iron. A recessed groove 153 is formed at a part corresponding to the opening 156 of the thin plate 151, which is larger than the opening 156 in plane and has a depth of 0.5mm. ~~As compared~~

Comparing a case with the groove 153 in the reinforcing member 152 with a case without the groove 153, an outline of the openings 156 is more clearly recognizable by the CCD camera 175, when the groove 153 is formed. The reason for this will be explained as follows. If the groove 153 is not formed in the reinforcing member 152 as in Fig. 9, a light 201 entering to irradiate an inner wall face 202 of the opening 156 is reflected at the reinforcing member 152, and returned toward the CCD camera 175. Additionally, a light 203 entering the reinforcing member 152 directly through the opening 156 is sometimes reflected by the reinforcing member 152 and the inner wall face 202 to be returned toward the CCD camera 175. On the other hand, when the groove 153 is formed as shown in Fig. 10, the light 201 entering to irradiate the inner wall face 202 of the opening 156 is reflected toward the groove 153 and not returned toward the CCD camera 175. Because of the presence of the groove 153, unnecessary light never enters the CCD camera 175. That is, the groove 153 works to let the CCD camera 175 recognize the outline of the opening 156 more distinctly.

The groove 153 is made larger in plane than the opening 156 so as to work the above-mentioned action, as described earlier. In other words, the groove 153 is required to be so large as not to be in touch with a

circumference 157 of the opening 156 at the side of the reinforcing member 152, as in Fig. 10. According to the embodiment, the groove 153 is formed concentrically with the openings 156, and a diameter III of the groove 153 is approximately twice the diameter of the opening 156, more specifically, 0.4-1mm in the present embodiment.

An inner face of the groove 153 is applied, e.g., in black to hardly reflect the light from the LED illuminator 171 of the component recognition device 107. Therefore, in a state with the reinforcing member 152 bonded to the thin plate 151, the light advancing through the opening 151 to the groove 153 is not reflected at the inner face of the groove 153.

The ~~constitution as above~~ above construction improves the dark-bright contrast between the picked-up face 151a of the thin plate 151 and the opening 156.

The groove 153 is not formed at a central part 155 of the reinforcing member 152, and therefore the central part 155 can support the thin plate 151.

The thus-constituted calibration jig 150 is directly sucked and held by the nozzle 110 of the component holding device 106 as will be discussed later. However, in the case where the nozzle is rendered detachable ~~to~~ from the component holding device 106, a detachment member 222, and the thin plate 151 and the reinforcing member 152 can

be formed integrally into a calibration jig 221 shown in Fig. 11.

Moreover, the calibration jig 150 may be adapted to be sucked indirectly as shown in Figs. 12 and 13. That is, a calibration jig 231 of the type is composed of a cup-like nozzle cover 234 forming a suction chamber 233 through contact with a flange part 232 of the nozzle 110, the thin plate 151 and reinforcing member 152 set at a bottom face of the nozzle cover 234 and, projecting parts 235. The nozzle 110 can be inserted into the nozzle cover 234. Holes 236 to be engaged with the projecting parts 235 are formed in the flange part 232.

In a state with the nozzle 110 inserted into the suction chamber 233 in the calibration jig 231~~—of the~~ constitution, a gap 237 is formed between a leading end of the nozzle 110 and a bottom face inside the suction chamber 233. The suction by the nozzle 110 turns the interior of the suction chamber 233 into a negative pressure, so that the flange part 232 and nozzle cover 234 are tightly in contact with each other, and accordingly the calibration jig 231 is fitted to the nozzle 110. The projecting parts 235 and holes 236 are a guide member for positioning the nozzle 110 and the calibration jig 231 roughly to prevent the flange part 232 and nozzle cover 234 from shifting greatly and disabling the suction chamber 233 to be

turned to the negative pressure.

The calibration jig 231, as described above, exerts the following effects.

5 The calibration jig 150 is large ~~relatively~~
relative to the electronic component sucked and held by the
component holding device 106 of the component mounting
apparatus 100. Therefore, a special suction nozzle for
sucking and holding of the calibration jig 150 is needed in
some cases, although a use frequency of this special
10 suction nozzle for the calibration jig 150 is considerably
low in comparison with the electronic component suction
nozzle. From the viewpoint of the structure of the
apparatus, it is not preferable to provide the special
suction nozzle for the calibration jig 150.

15 In the meantime, if the above-described
calibration jig 231 is used, the electronic component
suction nozzle can suck and hold the calibration jig,
thereby eliminating the need for the special suction nozzle
for the calibration jig 150.

20 The above calibration jig 150 is used in the
component mounting apparatus 100 constituted as in Fig. 8
according to the embodiment.

 The component mounting apparatus 100 for mounting
electronic components includes a board transfer device 102
25 for carrying in and out a circuit board 101 and holding the

circuit board when an electronic component is mounted to the board, a reel-type electronic component feed device 103 or a tray-type electronic component feed device 104 storing electronic components to be mounted, the component holding device 106 which can be moved in X, Y directions by an XY robot 105 to set the electronic component held from at least either the electronic component feed device 103 or the electronic component feed device 104 to a mount position on the circuit board 101, the component recognition device 107 for picking up an image and measuring an attitude of the electronic component held by the component holding device 106, and a control device 115 for controlling operations of at least the XY robot 105, component holding device 106 and component recognition device 107. The component holding device 106 is provided with the nozzle 110 for holding an electronic component 111, e.g., by sucking, and a board recognition camera 109 for picking up and recognizing board marks 112a, 112b marked at the mount position on the circuit board 101. A reference numeral 108 is a nozzle station where the nozzle 110 of the component holding device 106, the calibration jig, etc., are disposed.

As indicated in Fig. 1, the component recognition device 107 has the LED illuminator 171 for illuminating the calibration jig 150 held by the nozzle 110 and the

electronic component 111 in order to pick up images thereof,
a mirror 173 and a lens 174 arranged on an optical path of
a light reflected by the jig 150 or component 111, and the
CCD camera 175 for detecting a light passing the lens 174.
5 The LED illumination 171 is connected to an illumination
device 172 and the CCD camera 175 is connected to an image
processing device 176. The image processing device 176
operates information, which is required to calibrate the
component recognition device 107 with the use of the
10 calibration jig 150, such as a rotational angle of the
camera, etc. to be described later and then sends out an
operation result to the control device 115. The
calibration operation will be described in detail later.
The control device 115 controls an attitude of the
15 component 111 held by the nozzle 110 of the component
holding device 106 with the information of the rotational
angle, etc., taken into account as will be depicted later.

In the component recognition device 107, for
instance, the light of the LED illuminator 171 reflected at
20 the calibration jig 150 is condensed via the mirror 173 by
the lens 174, so that an image of the calibration jig 150
is picked up by the CCD camera 175. A reference numeral
177 ~~is~~ denotes an optical axis.

Now, the operation of the component mounting
25 apparatus 100 will be described below primarily in relation

to the calibration operation of the component recognition device 107 with the use of the calibration jig 150.

Before the electronic component 111 is started to be mounted ~~to~~ on the circuit board 101, the component
5 recognition device 107 should be calibrated first. As previously ~~discussed—before~~, the calibration of the component recognition device 107 consists of a measurement of the resolution of the CCD camera 175 of the component
10 recognition device 107, the rotational angle of the component recognition device 107 and the center position of the view field of the CCD camera 175, and a succeeding correction of the rotational angle and the movement amount of the sucked component by the component holding device 106 on the basis of those measured values. Each measurement
15 operation will be described specifically hereinbelow with reference to Fig. 14.

In step 1 in Fig. 14 ("S" in the drawing is an abbreviation of "step"), the picked-up face 151a of the calibration jig 150 is photographed by the component
20 recognition device 107. Fig. 3 is a diagram of a state when the picked-up face 151a of the calibration jig 150 is photographed by the component recognition device 107. Fig. 4 is a graph of a luminance level of an image along a line I-I of Fig. 3. The image in Fig. 4 is expressed by 256
25 gradations of the luminance from a darkest part to a

brightest part, more specifically, a part designated by a reference numeral 181 corresponds to the picked-up face 151a faced with the ~~satin-finished~~finish, and a part of a reference numeral 182 corresponds to the opening 156.

5 Since the calibration jig 150 of the above-described ~~constitution~~construction is used in the embodiment, a boundary between the bright and dark parts is made clear as in Fig. 4, whereby the part of the opening 156 can be recognized surely and clearly through processing of the

10 image.

In step 2, the center position of the calibration jig 150 is obtained. That is, the center position of each opening 156 is detected as the center of the area of each opening 156. The outline of the opening 156 of the

15 calibration jig 150 of the embodiment is clearly recognized in the image obtained by the component recognition device 107, so that information of each position described below and the center position can be specified correctly. Regarding each of four rows of the openings 156 aligned

20 along the rectangular outline, each line 185-188 is obtained as in Fig. 5 on the basis of center positions of openings 156 in each row according to an approximation of least squares. Further, intersections 189-192 of the lines 185-188 are obtained on the basis of the lines 185-188,

25 based on the intersections 189-192 a center position 193 of

the rectangular shape formed by the alignment of the openings 156 is obtained. The center position 193 corresponds to the point to be measured of the calibration jig 150.

5 After the center position 193 is detected, in step 3, the component holding device 106 holding the calibration jig 150 is moved over the component recognition device 107 in X, Y directions and, each center position 193 is obtained at each movement position in the above manner.

10 Supposing that the center position 193 changes from $O_a \rightarrow O_b \rightarrow O_c$ through the above movement in X, Y directions as shown in Fig. 6, the rotational angle and the resolution scale of the camera are obtained in step 4 in a manner as follows. That is, while it is naturally ideal that a

15 horizontal line in the image obtained by the component recognition device 107 is coincident with, e.g., X direction of the XY robot 105, actually there is present a slight error and the error corresponds to the rotational angle of the camera. Therefore, an angle $\Delta\theta$ defined by a

20 line 194 connecting the O_a and O_b and a horizontal line 195 of the component recognition device 107 is obtained on the basis of position information of the O_a and O_b . The angle $\Delta\theta$ corresponds to the rotational angle of the camera, i.e., the rotational angle of the component recognition device

25 107.

The resolution scale of the CCD camera 175 can be easily calculated from a movement amount on a screen of the component recognition device 107 and an actual movement amount of the nozzle 110. Specifically, a ratio of a distance L_x between the O_a and O_b when the component holding device 106 is moved in the X direction, and a distance between the O_a and O_b on the image, and also a ratio of a distance L_y between the O_b and O_c when the component holding device 106 is moved in the Y direction, and a distance between the O_b and O_c on the image are obtained, which are set as the resolution scale of the camera.

According to the embodiment, in the coordinate system of the component holding device 106, a rotational center in the rotation about the axis of the nozzle 110 is a bench mark. Therefore, in order to position the electronic component 111 correctly to the mount position on the circuit board 101, the rotational center of the nozzle 110 should agree with a center of the electronic component 111 held by the nozzle 110 and moreover agree with a center of the view field of the component recognition device 107. However, a slight offset is sometimes brought about therebetween and should be corrected. For the correction, as shown in Fig. 7, the calibration jig 150 held by the nozzle 110 is rotated every 90° over the component

recognition device 107 by rotating the nozzle 110 about its axis by every 90°, whereby positions 01, 02, 03, 04 corresponding to each center position 193 in the every 90° are recognized at every rotation. A coordinate value of the rotational center 196 of the nozzle 110 is calculated from an average of X coordinate values at the positions 01-04 and an average of Y coordinate values at the positions 01-04.

A coordinate value of the center of the view field of the component recognition device 107 can be similarly calculated, for example, by photographing a face to be photographed of the component recognition device 107, e.g., by the board recognition camera 109 of the component holding device 106.

The offset value of the center of the view field of the component recognition device 107 is calculated from the above ~~these~~ information according to an equation below.

Offset value = (coordinate value of nozzle 110 of component holding device 106 of XY robot 105 at measurement time) - (coordinate value of rotational center 196 of nozzle 110) - (coordinate value of center of view field of component recognition device 107).

The operation of mounting the component is carried out in compliance with the control by the control device 115 in consideration of the rotational angle and

resolution scale of the camera of the component recognition device 107 and the offset value of the center of the view field obtained as above taken in account. ~~Concretely~~Specifically, the circuit board 101 is

5 transferred to a mount place by the board transfer device 102. The component holding device 106 is arranged above the circuit board 101 by the XY robot 105, and board marks 112a, 112b on the circuit board 101 are picked up by the board recognition camera 109 set in the component holding

10 device 106, thereby recognizing a position where the electronic component 111 is to be mounted. Then, the XY robot 105 moves the component holding device 106 to, e.g., over the component feed device 103 to hold the electronic component 111 by the nozzle 110, e.g., by sucking. After

15 the electronic component 111 held by the nozzle 110 is arranged by the XY robot 105 above the face to be photographed of the component recognition device 107, the component holding device 106 moves down the nozzle 110 to a focus face of the component recognition device 107. The

20 electronic component 111 is illuminated by the LED illuminator 171 of the component recognition device 107. The image picked by the CCD camera 175 is sent to the image processing device 176. The image processing device 176 operates an attitude of the sucked electronic component 111

25 with the use of the center position 193, rotational angle

$\Delta\theta$ of the camera, resolution of the CCD camera 175 and offset value of the center of the view field at the component recognition device 107. The control device 115 consequently corrects the operation of the XY robot 105 and component holding device 106 based on the operation result supplied from the image processing device 176, to mount the electronic component 111 held by the nozzle 110 to the circuit board 101. The same operation is executed for each subsequent electronic component 111~~afterwards~~.

10 In the embodiment using the calibration jig 150, the component recognition device 107 can clearly recognize the bright-dark contrast of the jig 150. The rotational angle of the camera, resolution and offset value of the center of the view field of the camera of the component recognition device 107 can be correctly obtained. Accordingly, the component holding device 106 can be corrected with higher accuracy as compared with the conventional art. The component is hence correctly mounted to the board.

20 The calibration jig 150 in the above embodiment comprises the thin plate 151 and reinforcing member 152. The reinforcing member 152 may be eliminated if the thin plate 151 has high strength. In such case, a recess-shaped member having an inner face applied, e.g., in black should be set at a position corresponding to the openings 156 at

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the rear side of the picked-up face 151a so as to suppress the reflection of light, thereby obtaining the clear contrast between the picked-up face 151a and openings 156.

Although the present invention has been fully
5 described in connection with the preferred embodiment thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the
10 scope of the present invention as defined by the appended claims unless they depart therefrom.

ABSTRACT OF THE DISCLOSURE

~~The present invention provides a~~ A calibration jig for a component recognition device and a component recognition calibration method using the jig which can stabilize ~~mount~~ the mounting accuracy of a component to a to-be-mounted object and improve mount quality. An opening is formed at a to-be-picked-up face of the calibration jig. A predetermined position of the calibration jig is recognized on the basis of the contrast between the picked-up face and the opening. The position of the calibration jig can be recognized with higher accuracy, so that a resolution of the component recognition device, etc. can be obtained with a higher degree of accuracy. Mount accuracy of the component to the object is thus stabilized and mount quality is improved.

~~According to the present invention, an opening is formed at a to-be-picked-up face of the calibration jig. A predetermined position of the calibration jig is recognized on the basis of the contrast between the picked-up face and the opening. In comparison with the conventional art that a position of the calibration jig is recognized on the basis of an outline of the calibration jig, the position of the calibration jig can be recognized with higher accuracy, so that a resolution of the component recognition device, etc. can be obtained with higher accuracy than in the~~

~~conventional art. Mount accuracy of the component to the
object is thus stabilized and mount quality is improved.~~